DOCUMENT RESUME

ED 283 686 SE 048 221

AUTHOR Blosser, Patricia E., Ed.; Helgeson, Stanley L., Ed.

TITLE Investigations in Science Education. Volume 13, Number 2, 1987.

INSTITUTION Ohio State Univ., Columbus, Ohio. Information Reference Center for Science, Mathematics, and Environmental Education.

PUB DATE 87

NOTE 69p.

AVAILABLE FROM SMEAC Information Reference Center, The Ohio State University, 1200 Chambers Road, 3rd Floor, Columbus, OH 43212 (U.S. subscription $8.00; $2.75 single copy).

PUB TYPE Collected Works - Serials (022) -- Reports - Research/Technical (143) -- Information Analyses (070)

JOURNAL CIT Investigations in Science Education; v13 n2 1987

EDRS PRICE MF01/PC03 Plus Postage.

DESCRIPTORS Biology; Chemistry; Cognitive Processes; Cognitive Style; College Science; Ecology; Elementary Secondary Education; Foreign Countries; Instructional Improvement; *Learning Strategies; *Misconceptions; Questioning Techniques; *Science Curriculum; Science Education; *Science Instruction; *Science Teachers; Teacher Attitudes; *Teaching Methods

IDENTIFIERS Canada; *Science Education Research

ABSTRACT

Abstracts and abstractors' critiques of ten published articles related to curriculum, misconception research, and instruction are presented. Aspects addressed in the studies include: (1) Canadian teachers' opinions on changes in elementary and junior high school science programs; (2) current status of ecology education in Illinois; (3) meta-analysis report of the effects of ISCS Program; (4) impact of selected elementary science programs on classroom practices; (5) medical students understanding of natural selection; (6) junior high school age students' explanations of chemical reactions; (7) teaching children to ask operational questions; (8) alienation of students from science; (9) lesson structure and cognitive style and science achievement of elementary school children; and (10) effects of text questions of various types of retention of biology concepts by college students. Included for each study are purpose, research design and procedure, and findings and interpretations. A critique follows each review. (ML)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED283686

INVESTIGATIONS IN SCIENCE EDUCATION

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
X This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Editor

Patricia E. Blosser
The Ohio State University

Associate Editor

Stanley L. Helgeson
The Ohio State University

Advisory Board

David R. Stronck (1987)
California State University-Hayward

Susan Johnson (1988)
Ball State University

Dorothy Gabel (1987)
Indiana University

John Penick (1988)
University of Iowa

John J. Koran, Jr. (1989)
University of Florida

National Association for Research in Science Teaching

ERIC Clearinghouse for Science, Mathematics, and Environmental Education

INVESTIGATIONS IN
SCIENCE EDUCATION

Volume 13, Number 2, 1987

Published Quarterly by

SMEAC Information Reference Center
The Ohio State University
1200 Chambers Road, 3rd Floor
Columbus, Ohio 43212

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Robert N.
Iowa
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Subscription Price: $8.00 per year. Single Copy Price: $2.75.
Add $1.00 for Canadian mailings and $3.00 for foreign mailings.

Volume 13, Number 2, 1987

NOTES FROM THE EDITOR iii

CURRICULUM 1

Stronck, David R. "Trends in Teachers' Recommendations for Changing Elementary and Junior-High School Science Programs." Journal of Research in Science Teaching, 23 (3): 201-207, 1986.
Abstracted by JOHN PENICK. 3

Barber, B. H. and A. N. Tomera. "Is Ecology Being Taught in General Biology Classrooms?" School Science and Mathematics, 85: 285-297, 1985.
Abstracted by STEVEN W. GILBERT. 7

Atash, M. Nadir and George O. Dawson. "Some Effects of the ISCS Program: A Meta Analysis." Journal of Research in Science Teaching, 23 (5): 377-385, 1986.
Abstracted by DAVID R. STEVENSON 12

Bredderman, T. "The Influence of Activity-Based Elementary Science Programs on Classroom Practices: A Quantitative Synthesis." Journal of Research in Science Teaching, 21: 289-303, 1984.
Abstracted by KEVIN WISE 18

MISCONCEPTIONS 25

Brumby, Margaret N. "Misconceptions about the Concept of Natural Selection by Medical Biology Students." Science Education, 68 (4): 493-503, 1984.
Abstracted by RICHARD TOLMAN 27

Andersson, B. "Pupils' Explanations of Some Aspects of Chemical Reactions." Science Education, 70 (5): 549-563, 1986.
Abstracted by GLEN AIKENHEAD 35

INSTRUCTION. 41

Allison, A. Wayne and Robert L. Shrigley. "Teaching Children to Ask Operational Questions in Science." Science Education, 70 (1): 73-80, 1986.
Abstracted by DONALD E. RIECHARD 43

James, R. K. and S. Smith. "Alienation of Students from Science in Grades 4-12." Science Education, 69 (1): 39-45, 1985.
Abstracted by EDMUND A. MAREK. 50

Yore, Larry. "The Effect of Lesson Structure and Cognitive Style on the Science Achievement of Elementary School Children." Science Education, 70 (4): 461-471, 1986.
Abstracted by JOHN W. RENNER 56

Leonard, William H. and Lawrence F. Lowery. "The Effects of Question Types in Textual Reading Upon Retention of Biology Concepts." Journal of Research in Science Teaching, 21 (4): 377-384, 1984
Abstracted by JOEL J. MINTZES. 62

NOTES FROM THE EDITOR:

The second issue of Volume 13 of INVESTIGATIONS IN SCIENCE EDUCATION contains critiques of published articles in science education research relating to curriculum (four reports), misconception research (two reports), and instruction (four reports).

Within the curriculum section, Stronck reported on the results of a survey of Canadian teachers' opinions on changes in elementary and junior high school science programs. Barber and Tomera surveyed Illinois science teachers to determine the current status of ecology education in that state. Atash and Dawson used meta-analysis techniques to study the effects of ISCS as compared to traditional junior high science courses on student performance and attitudes. In another meta-analysis report, Bredderman synthesized findings about the impact of the elementary science programs ESS, SCIS and SAPA on classroom practices.

In the misconceptions section, Brumby investigated the understanding that first year medical students had about the concept of natural selection. Andersson reviewed six studies related to junior high school age students' common sense explanations of chemical reactions.

The learning section contains a critique of a report by Allison and Shrigley on teaching children to ask operational questions. James and Smith examined data regarding the grade level(s) in school at which alienation to science occurs. Yore investigated whether or not achievement of elementary school students with low perceptual structure could be modified by lesson structure. Leonard and Lowery looked at the effects of text questions of various types of retention of biology concepts by college students.

Patricia E. Blosser
Editor

Stanley L. Helgeson
Associate Editor

CURRICULUM

Stronck, David R. "Trends in Teachers' Recommendations for Changing Elementary and Junior-High School Science Programs." Journal of Research in Science Teaching, 23 (3): 201-207, 1986.

Descriptors--Canada; Elementary School Science; Elementary School Teachers; Inservice Education; *Needs Assessment; School Surveys; Science Activities; *Science Education Research; Secondary School Science; Secondary School Teachers; *Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by John Penick, University of Iowa.

Purpose

By surveying 3,040 Canadian teachers in 1978 and 1,631 in 1982, this research provides evidence of trends in teacher recommendations for changes in elementary and junior high school science programs.

Research Design and Procedure

A random sample of all science teachers in British Columbia who had not completed a government questionnaire that year included both elementary and secondary school teachers.

About 80% of those surveyed responded to the British Columbia Science Assessment, rating 16 aspects of their school science program in terms of appropriations and need. At the same time, respondents provided a description of their own teaching practices through 19 Likert-style questions on teaching strategies.

In addition, teachers provided demographic information about themselves. Some teachers were involved in both the 1978 and 1982 surveys. Returns were probably high since questionnaires were distributed by the Ministry of Education. Fewer teachers were selected in 1982 (N = 1,631) than in 1978 (N = 3,040), reflecting, perhaps, the increased use of government questionnaires.

Responses were rank ordered for each of the two years and Spearman Rank Order Correlations provided an indication of effect.

Findings

Actual practice. Stronck found that a 1978 rank order of various teaching activities used by elementary teachers differed only slightly from the ranking of the science activities in 1982. Of the four that were different in 1982, two, "Listening to teacher's explanations" and "Answering questions from work sheets or textbooks" increased. Two decreased, "Doing library research" and "Doing investigations at home." Elementary teachers still feel that "Describing/reporting observations in their own words" is the most common activity.

Junior/secondary school teachers reported similar ideas except in their rank-ordering of student activities, "Answering questions from work sheets and textbooks" is the most frequent activity, a change from 1978. "Listening to teacher's explanations" and "Memorizing scientific information" also became more common while students were less likely to do library research or solve quantitative problems. Teachers still rate "Carrying out experiments from a set of instructions" as very desirable.

Suggested changes. When asked what should be changed in schools, elementary teachers want more "activity-centered learning" and less "outdoor education." Their first suggestion for change in 1978, "Background information for teachers" fell to second place while the 1982 winner, "Provision of print materials other than textbooks" rose from second place.

Junior/secondary school teachers reported no real changes between 1978 and 1982 with "Alternate programs in science" and "Background information for teachers" both receiving a high priority.

Interpretations

Stronck suggests that the trend toward emphasizing memorization reflects that teachers become tired as they age, getting beat down by the system, and by a lack of inservice opportunities. At the same time, reduced budgets for professional travel, journals, and laboratory materials may increase the dependency on print materials and traditional activities. He goes on to suggest increasing inservicing and improving facilities.

Much research has been reported on what teachers want, need, and do. While this study does not shed new light on an old situation, it is a large sample and Canadian as well. Disregarding possible methodological considerations such as degree of randomness, duplicity of subjects, or completeness of choices, this type of research does provide some insight into the action and thinking of these teachers.

For instance, it's hard to ignore that "Describing/reporting observations in their own words" is the most frequently reported activity in elementary schools in 1978 and 1982. Certainly, no one would say this is far misplaced. And, when the top seven of the top eight in both years include "Making guesses", "Interpreting for themselves," "Measuring," "Classifying," "Generalizing," and "Discussing with other students," it does appear that elementary science teachers in British Columbia are right on the mark with their basic notions of what students should be doing. This image of an activity-centered class, truly reflecting the nature of science, becomes more reinforced as you note that three of the least occurring activities include "Copying notes from the blackboard/overhead projector," "Doing library research," and "Memorizing scientific information." Unfortunately, "Making up their own experiments" is last or next to last each year in these elementary classrooms.

Junior/secondary school teachers report activities in a similar fashion, although with less agreement between 1978 and 1982. In 1983, the teachers report six out of the most frequent eight activities as what most would describe as process-centered and activity oriented. Again, though (I am tempted to say "unfortunately, once again"), "Answering questions from work sheets and textbooks" moved from 13th to first while "Making up their own experiments" remained in last place both years.

So, at both age levels an image of students following recipes, answering pre-ordained questions, and applying some processes of science to artificial, external, and confirmatory activities prevails. If no true experiments are underway, how can we call it science? Obviously, Stronck is right on the mark when he calls for increased inservice for teachers.

But, equally important is a need to measure more validly the activities and actions of both students and teachers. Self-reporting from a forced choice list does not lend itself as a model that will best reflect the reality that is schooling. This becomes particularly true as one recalls that teachers may be reporting on desired rather than actual classroom practice. And, who among us can really rank order 18 of our practices? Then, are the suggested changes changes in reality or the imagination? How can we use these data for designing inservice when we cast doubt on its validity? Or, do we just continue with inservice as we always have, trying to move ahead from our own perceptions of need?

All of this suggests (seemingly as do all studies) the need for more research, better control, more subjects, and more time. But, will any of this really suffice? Certainly knowing what teachers do can be a sufficient basis for designing procedures for change but is it all that necessary? Perhaps smaller studies with more precise questions or actual classroom observation might do as well or better.

Clear documentation of actual practice provides a firm foundation for both change and progress. Such documentation often arises out of surveys and comes about as money and opportunity become available. At the same time, similar studies of inservice meetings might reveal weaknesses there, as well. And, let's not neglect preservice teacher education. Perhaps as we develop a true and strong correlation between perceived societal needs, preservice and inservice education, and school practice we will find true meaning and utility in surveys such as this.

Barber, B. H. and A. N. Tomera. "Is Ecology Being Taught in General Biology Classrooms?" School Science and Mathematics, 85: 285-297, 1985.

Descriptors--*Biology; Course Content; *Ecology; High Schools; Science Education; *Science Instruction; Science Teachers; *Secondary School Science; Teacher Attitudes; *Teaching Methods; *Textbook Content; Textbooks

Expanded abstract and analysis prepared especially for I.S.E. by Steven W. Gilbert, Southwest Texas State University, San Marcos.

Purpose

This survey of Illinois secondary science teachers was undertaken to partially determine the current status of ecology education, and to measure biology curriculum orientation toward an understanding of science-related societal issues. Data were gathered on the type of textbooks used, the presentation of ecology in the texts, the degree of utilization of textbooks, the use of instructional resource materials, the instructional methods teachers employed, the teachers' perceptions of the importance of ecology, the ecological concepts taught, and the environmental problems discussed.

Rationale

Ecology is an important basis for the understanding of science-related societal issues and for achieving the goal of creating environmentally literate citizens. It is an important component of the Science/Technology/Society thrust in science education. Therefore, it is important to have measures of how ecology is currently being taught in the schools, and the degree to which it is being discussed.

Research Design and Procedure

The research was conducted using a simple mail survey, with no reported followup. The questionnaire was sent in Autumn, 1981, to a randomly selected sample of secondary biology teachers in Illinois. The sample represented 20% of the total available population, and was stratified by educational service regions. Teachers who taught biology during the 1980-81 or 1981-82 school years were included. There were 156 usable responses, which represented approximately 69% of the sample.

Findings

There were a large number of findings, the more important of which are briefly summarized below:

1. Most of the respondents (83%) had recieved instruction in ecology, averaging 2 formal courses.
2. Illinois teachers tend to use a single textbook. Modern Biology, Biology, Living Systems, Biology (Scott Foresman) and BSCS green version together hold 78% of the market.
3. Some 85% rated their texts as good or excellent in presenting ecological concepts, and 72% rated the emphasis as appropriate. About 87% said the texts did a good job of applying ecological concepts toward environmental problems.
4. The majority of respondents (75%) always or often used the text. Most supplemented it with other resources. Only 2% did not use the text.
5. Films were often used; journals, magazines, newspapers and filmstrips sometimes were used; and slides, audiotapes and records seldom or never used.
6. About 65% of respondents seldom or never used community resource personnel.
7. About 27% of respondents always used lecture and 32% often did.
8. Student reports are "seldom" or only "sometimes" used to teach ecology.

9. Over half the respondents seldom or never use field trips for ecology teaching.
10. Ecology was rated by teachers as the third most important topic in the curriculum (after genetics and cellular biology).
11. Some 87% of respondents dealt with ecological concepts in their general class, though 90% taught the "community" and "ecosystem" concepts.
12. Fewer than 60% included the concept of humans as an ecosystem component, though 76% said they focused on the ecological implications of human activities and communities.
13. Around 93% of the 136 teachers who taught ecology covered environmental problems, averaging 8 problems each.
14. Overpopulation was discussed by 80% of the 127 teachers who discussed environmental problems.
15. Two-thirds of the teachers who discussed environmental problems also discussed endangered animals, air pollution, water pollution, and energy consumption.

Interpretations

Most teachers supplement their textbook. This being the case, publishers and developers should consider these supplementary needs when they evaluate their texts. Teachers should communicate these needs to publishers. On the other hand, it is doubtful that reliance on the text is sound educational practice. It may be that teachers should not rely only on the text, even if publishers did make modifications.

Illinois biology teachers seem to employ methods that can be used within the classroom. They should be encouraged to increase their instructional methods to encourage active learning.

The inclusion of ecology as one of the five most important biology topics may indicate that teachers are moving away from the more traditional phylogenetic approach and focusing on more relevant content.

Teachers need to apply ecological concepts to environmental problems. The data suggest that discussion of environmental problems may occur in some classrooms without the students first exploring the relevant basic principles of ecology. For instance, a majority of the teachers discuss overpopulation but far fewer teach population dynamics, and few include humans as ecological components. It is suggested that ecological underpinnings may need to come before the understanding of environmental problems.

ABSTRACTOR'S ANALYSIS

Good survey work which will give us a better picture of the educational situation as it exists is always welcome. As it was set up, this model appears to be a useful one and one which may be assumed to represent the situation in many other parts of the United States than Illinois. No rationale was given for restricting the survey to Illinois, and without such an explanation, one is left wondering why the researchers did not go farther afield and work at a national level. This would have involved more work in identifying participants, but would have had the benefit of reducing the influence of nonrandom political variables.

The stratified random sampling technique appears reasonable, although a followup to collect additional responses might have been a useful addition. It seems logical to assume that teachers who don't teach ecology might be less inclined to answer a questionnaire on the topic than those who do, thus skewing the sample somewhat. It is doubtful that this is a serious criticism, as long as this possibility is kept in mind.

As a science teacher educator, I found the results interesting, and mentally compared the author's findings to my own observations in various classrooms. Many of the findings are related less to the ecological variable than to science teaching as a whole, and will usefully contribute to our understanding of the current state of science education. The straightforward presentation of data is appreciated and a welcome change from the grueling regimen of (sometimes unnecessary) statistics that typify more sophisticated work. However, in some cases a more numerical presentation might

have been appreciated. An average response of "seldom" or "always" might be better reported numerically, as a mean response value. For instance, the statement "Data indicate that Illinois teachers 'sometimes' make use of supplemental ecological readings..." loses information value as a tradeoff for easy readability, and will certainly be difficult to quantify for future meta-analysis.

Perhaps the major difficulty I had with this work was the rather weak commentary and summarization. Certainly the data were interesting, but then what? One gets a feeling that the authors themselves were not sure of what to make of their creation. For instance, the suggestion by the authors that publishers make use of the presented knowledge to improve their product was immediately countered by the suggestion that this might not be an educationally sound idea, leaving the reader confused as to the authors' own opinions on the matter. No resolution of these two seemingly incompatible views was offered.

Similarly, other observations and speculations in the commentary seem anemic (though not without some substance) in view of the amount of data collected. What is lacking is a substantial integration of this information into the S/T/S paradigm. The articulation of the new model to existing theory is incomplete and weak. A more complete integration of the findings into the extant literature would have greatly enhanced the value of this work. Similarly, overt suggestions for new directions in research would have been useful.

In summary, this is good baseline research. It is directly and simply written, easy to understand, and has practical implications. If one knows where to look, new research possibilities present themselves. For instance, do students who have an ecological foundation for their study of overpopulation really develop more understanding of the problem than those who don't? Does the use of supplementary materials really generate more understanding and interest than the use of the text? Is there a correlation between the ranking of a topic by teachers and its inclusion in their curriculum? Why do teachers consider some ecological concepts and environmental problems to be more important than others? Portrayal of an existing state is a prerequisite to finding the proper direction for change. In the end, that is the value of this work, and perhaps is what should have been emphasized in its commentary.

Atash, M. Nadir and George O. Dawson. "Some Effects of the ISCS Program: A Meta Analysis." Journal of Research in Science Teaching, 23 (5): 377-385, 1986.

Descriptors--*Academic Achievement; Junior High Schools; *Meta Analysis; *Science Course Improvement Projects; Science Education; *Secondary School Science

Expanded abstract and analysis prepared especially for I.S.E. by David R. Stevenson, Truro, Nova Scotia.

Purpose

The purpose of the investigation was to use the techniques of meta-analysis to study the effects of the ISCS program as compared to traditional junior high science courses on student performance and attitudes. Only studies which had been done in the United States and which contained a comparison of the stated groups were included. Two questions provide the focus for the investigation:

1. How do students exposed to ISCS compare to students exposed to traditional junior high science courses on specified performance criteria?
2. Can design of the study, type of instrumentation, and reliability of the instrument account for significant variation in the effect size?

Rationale

The ISCS program has been available for more than fifteen years, during which time it has become widely used in junior high schools. Its characteristics (semi-programmed, individualized) compared to previous programs, the publication of a commercial version, and its acceptance in other countries support in-depth study of the effects of the program.

The research, using the meta-analysis techniques developed by Glass (1976), provides an opportunity to be objective in assessing

results of studies because of the quantitative comparisons which are the outcome of the investigation.

Research Design and Procedure

Of a potential total of 45 studies located through a literature search, ten were found suitable because they met the criterion of containing a comparison of effects between ISCS students and students of traditional junior high science courses in the United States. The studies were all doctoral dissertations which contained sufficient data for analysis. Each separate outcome of the selected studies was coded, giving a total of 30 outcomes for analysis. Each outcome is call a "case" in the study. The clusters of components and the number of cases under investigation are given by the investigators:

General Description	Specific Components	Cases
Achievement	factual/recall, synthesis, analysis, general achievement	2
Perception	subject, science, self-concept, teacher or teaching technique	18
Process Skills	technique, methods of science	2
Analytical Skills	critical thinking, problem solving	3
Related Skills	reading, mathematics, social studies	3
Other Areas	logical thinking, spatial relations	2

The main features of the studies were identified as six variables: design of the study, sample size of each of the ISCS group and the control group, type of instrumentation, reliability of the instrument, and type of outcome. A seventh variable - validity of the instrument - was initially included but dropped, due to insufficient data.

The researchers conducted a series of calculations to make the outcomes comparable across the studies:

(a) Effect size (Glass, 1976): on each outcome to standardize the differences between treatment and control groups. A total of 30 ESs was calculated, with the pooled within-group standard deviation used when possible to reduce sampling error.

(b) Weighted mean effect size (Hunter, Schmidt, and Jackson, 1981): to integrate findings across the studies.

(c) Dispersion around the mean effect size: to calculate variation in effect size across all outcomes in the studies.

(d) Difference in variation of effect size controlling for sampling error: to determine if potential moderator variables should be sought. In the study three variables were considered: study design, instrumentation, and instrument reliability.

(e) Correlation of moderator variables with ES; correction of correlations for sampling error; reliability of effect size (Hunter, Schmidt, and Jackson, 1981): to locate moderator variables which account for a significant portion of variation in ES.

Findings

The investigators provide a summary of information about the studies which were analyzed, but it is not possible to identify the size of sample or the methodology that was used for studies which fell into each of the descriptive categories.

For the analysis taken as a whole, the mean effect size was 0.09; the standard deviation of the ES was 0.249; the standard error of the ES was 0.046. It was concluded that the results were statistically significant ($p = 0.05$) in favor of the ISCS students.

The results on clusters of components were varied:

General Description	M	SD	95% CI		In Favor Of
Achievement	-.45	.07	-.54	-.35	Traditional
Perception	.15	.25	.04	.27	ISCS
Process Skills	.09	.20	-.19	.37	-
Analytical Skills	-.01	.09	-.11	.09	-
Related Skills	.19	.03	.16	.22	ISCS
Other Areas	-.00	.31	-.44	.43	-

The analysis of data revealed that the size of the effect varied across the cases, which led to an examination of sampling error, and to residual variance. The variance of ES, controlled for sampling error, was found to be 0.044, and a search for moderator variables was made. There were three variables identified: study design, instrument reliability, and type of instrumentation. It was found that the design of the study accounted for a significant portion of ES variation, and that it together with sampling error account for 42% of variation in ES, leaving 58% unidentified.

Interpretations

The authors conclude that the composite effect size reveals that students of ISCS outperform those taking a traditional science program in junior high school. Further, if the results are assumed to be normal, the ISCS students perform at the 54th percentile compared to the 50th for the traditional program group.

The results were found by the investigators to be much as expected. Performance of the two groups of students should differ because of the difference in content between ISCS and a traditional program. Greater gains by ISCS students in related areas (see table above) have been attributed to peer teaching and to the characteristics of ISCS. The activity-based and individualized nature of ISCS is felt to account for better attitudes toward science exhibited by ISCS students. The small mean effect size is said by the authors to result in a large national change in content knowledge.

The investigators note the effect size suggests implications for researchers of program evaluation. The random assignment of subjects to treatment groups seems to create artificial environments which may reduce the results of the treatment program. It is stated that it may be appropriate to bring the innovation to already established classrooms.

ABSTRACTOR'S ANALYSIS

The investigation of ISCS was undertaken to determine answers to the two questions stated under "Purpose" above. Both questions were answered through the use of the meta-analytic technique described.

The study serves a function often overlooked by school practitioners: by investigating the research previously completed about a program over many characteristics, it is possible to learn, in some detail, the extent to which the program may be effective. However, the procedure is not readily available to the casual reader, and the report of the study is valuable to the educational community.

ISCS has received a wide acceptance and its effects may be more widely spread than can be measured. For science education this is a benefit. For the researcher, however, it could become more difficult

to devise measures which separate characteristics of this from other programs. One of the advantages which ISCS and other curriculum developments of their time have brought to the field has been the spread of techniques throughout science education. That ISCS had an initial influence has been accepted; the depth of the effect may still be open to discussion.

The investigators attempted to locate studies for the analysis by undertaking a wide search of the literature. There is no disadvantage in locating only doctoral dissertations as a result of the search, especially since a comparison of sample groups was a criterion. There may be need for comment, however, on the age of the studies. Given that the report was accepted for publication late in 1985, at least seven years had passed since the newest dissertation was filed, with another five years since the first was completed. Further, the topics of study within the dissertations give a clear direction to the analysis under review.

The focus on ISCS compared to "traditional junior high science courses" contains a suggestion which may not have been intended. The traditions of science education in North America made ISCS possible, even though a spectacular event may have been an immediate catalyst for program development. The extent to which teachers received an introduction to ISCS compared to other programs, or had the advantage of training in ISCS procedures, or had schools re-equipped to encourage ISCS use are all unknown factors in comparing student results. ISCS may have received endorsement as a result of university activities in some areas, and the positive effects could have remained for many years for all the right reasons.

In general, the review is presented in a clear manner. It sets forth in detail the issues to be investigated and it focuses on the topic throughout. It would be helpful, though, to have more information about some of the specific components which are being investigated, such as "teacher", "methods of science" compared to "teaching technique", and the difference between "critical thinking" and "logical thinking".

The results of the investigation under review satisfy the purposes of the research. A question may remain, however, about the interpretation given by the authors. What does it mean to have an

overall advantage in favor of ISCS, yet with the Achievement category toward the traditional programs, and with the Process and Analytic Skills categories showing no significant preference? Is it possible that the Perception and Related Skills categories can be explained reasonably because of other factors operating on teachers, students and schools where the studies were conducted?

The report is well presented, yet seems to break no new ground. It does add, however, to a growing body of investigation into the structure of science education in our schools. We may be going through a time in which the results of such studies are given more value than the underlying reasons for improvements in skills, attitudes, and knowledge: competent teachers, with adequate administrative support, and science programs with a balance between skill and cognitive development.

REFERENCES

Glass, Gene V. "Primary, Secondary, and Meta-Analysis of Research." Educational Researcher, 5 (10): 3-8, Nov. 1976.

Hunter, J. E., F. L. Schmidt and G. B. Jackson. "Integrating Research Findings Across Studies." A document prepared as part of the project Methodological Innovations in Studying Organizations, American Psychological Association, 1981.

Bredderman, T. "The Influence of Activity-Based Elementary Science Programs on Classroom Practices: A Quantitative Synthesis." Journal of Research in Science Teaching, 21: 289-303, 1984.

Descriptors--*Classroom Techniques; Elementary Education; *Elementary School Science; *Interaction; Questioning Techniques; *Science Course Improvement Projects; Science Education; *Science Instruction; Student Behavior; Teaching Methods; Time Factors Learning

Expanded abstract and analysis prepared especially for I.S.E. by Kevin Wise, Southern Illinois University, Carbondale.

Purpose

The purpose of this paper was to synthesize the findings of studies wherein the impact of the activity-based science programs ESS, SCIS, or SAPA on classroom practices was examined. It was hypothesized that if these programs change classroom practice as expected, then the group of studies synthesized should show that certain differences exist between the activity-based classrooms and those using "traditional"-type science instruction. Specifically, the activity-based classrooms should be characterized by: (1) increased student activity and decreased teacher and student talk, (2) increased student talk relative to teacher talk, (3) increased student-initiated talk relative to student-responsive talk, (4) increased teacher questioning relative to other types of teacher talk, (5) increased higher level questions relative to lower level questions and, (6) increased teacher procedural information giving.

Rationale

In a national survey by Weiss (1978), 20% of primary teachers and 30% of intermediate level teachers noted that they used one of the activity-based science programs, ESS, SCIS, or SAPA. Figures from the same survey, however, indicated that lectures and discussions are the predominant modes of instruction in science. Teaching practices

either have not been substantially influenced by the activity-oriented science programs or the 20-30% penetration rates reported for these programs were not high enough to have influenced the survey results.

Research Procedures

Studies initially identified during the literature search had to meet three criteria to be included in the synthesis. The studies had to involve: the use of ESS, SCIS, or SAPA; the use of a comparison or control group; and the use of a systematic means of coding classroom behavior by trained coders. A total of 11 studies met these criteria. As a group, the studies selected represented 467 teachers, 27 groups (classes of students, primary through grade six), and 1800 lessons.

As an initial step in the synthesis process, a common system for combining the findings of the studies was developed. A preliminary reading of all selected studies was used as a basis for structuring a composite teaching practices category system that included classroom practices for which it was reasonable to expect a difference between activity-based and traditional classrooms. The resulting system included the "competing" category pairs of: activity - talk; student talk - teacher talk; student initiated talk - student responsive talk; teacher questioning - teacher instructive talk; teacher lower level questions - teacher higher level questions; and teacher lecture versus teacher direction giving.

Data analyses were primarily directed at determining ways in which activity-based science lessons differed from traditional science lessons in terms of the teaching practices category system described above. The shift in percentage of time devoted to each competing pair of teaching practices was compared to the shift hypothesized for that pair.

Findings

The change for the two broadest competing category pairs of talk versus activity, showed a 10% increase in time devoted to activity and a 10% decrease in time devoted to talk in the activity-based

classrooms relative to traditional science classrooms. All comparisons for which data were available showed the same direction of shift, with a range of +1% to +33%.

Shifts for student versus teacher talk (7 studies, 11 comparions), student-initiated versus responsive-talk (6 studies, 11 comparisons), and teacher questions versus instructive talk (6 studies, 12 comparisons) were all small.

In the classroom time devoted to the information-giving activities of teachers, there was a 14% shift from lecturing to direction giving in the activity-centered classrooms. This direction of change was found in 10 of 11 comparisons, representing 6 studies.

There was essentially no change in the time devoted to questioning and a 3% decrease in the time devoted to higher level questions in activity-based classrooms. Four other studies contained data on the number of questions asked rather than the time spent questioning. On the average, 16% more higher level questions and 16% fewer lower level questions were asked in activity-based lessons than in traditional lessons.

Further analyses focused on the impact of teacher training in the activity-based science programs (16 comparisons from 11 studies). Untrained teachers, those given only teacher's guides, appear to change their teaching in the direction of that expected for activity-based programs the least. Student activity is increased only half as much as in classrooms with untrained teachers and it is done more inefficiently because of increased time spent on direction giving. Teachers who had received training were subdivided into those who did or did not get supervisory support beyond the training period. This comparison indicated that not much, if anything, is gained by providing supervisory support beyond training.

Interpretations

The profile of elementary science teaching practices compiled in this synthesis of studies differs in several findings from another somewhat similar effort reported in the literature. Dunkin and Biddle (1974) reviewed 25 studies in which the Flanders (or a related system of coding behavior) was used to document classroom events in a variety

of subject areas. In their summary, the data are expressed in fractional ranges frequently being based on only a few studies of particular grade levels and subject areas. Categories in the present analysis near or above the upper limit of the Dunkin Biddle ranges, are teacher questioning, total teacher talk, and student initiated talk. Such differences are presumed to reflect ways in which elementary science differs from other subject areas. Total talk and lecture in activity-based classrooms, on the other hand, are below ranges reported by Dunkin and Biddle. Decreased lecturing in the context of increased total teacher talk is probably a result of increased direction giving on the part of teachers. Teachers naturally tend to become more direct rather than more indirect when using activity-based lessons contrary to curriculum programs. However, the effect of training on decreasing the amount of direction-giving relative to the amount of student activity, found in the present analysis, suggests that training may be a significant factor in reducing this natural teacher dominance.

Another area of difference between activity-based and traditional type science teaching approaches is in the number of higher level questions asked. In a meta-analysis of studies of questioning behavior, Redfield and Rousseau (1981) found a relatively large positive effect on achievement test scores of students exposed to higher level questioning. Porterfield (1969) found that reading teachers trained in SCIS raised their level of questioning in reading lessons. It would seem that the level of questioning can be raised by specific training in activity-based science, and that the increased level of questions that would occur as a result of this training could produce increased student achievement.

Synthesizing data from research on classroom practices provides for generalizability of findings not possible with single studies. The present report suggests that in a broad context, program materials and teacher training (especially in combination with each other) can have noticeable and desireable effects on the way in which elementary science is taught.

ABSTRACTOR'S ANALYSIS

This study is unique in its examination and synthesis of investigations wherein the actual practices of activity-based and traditional elementary science programs are compared. Other syntheses of investigation dealing with the activity-based elementary science curriculum programs (ESS, SCIS, and SAPA) have focused on the effect of these programs on student achievement rather than practices employed during instruction. In meta-analyses by both Shymansky, Kyle, and Alport (1983) and Bredderman (1983), it was found that the average student in classes using the "new" elementary science curricula exceeded the performances of most of the students in traditional programs. With these striking results in favor of the activity-based science programs, a study such as the present one is of interest and value. If activity-based science instruction is as potent as the research suggests, then a careful review of the instructional events that typically occur during such lessons can be used to help explain why these curricula have such favorable impacts, and to suggest how these impacts may be enhanced.

Some interesting information is generated in this study through examination of percentages of the total lesson time devoted to each classroom practice category. Traditional science lessons involved an average of 80% talk time and 10% of activity time. This breakdown would not surprise most science educators. However, in activity-based lessons a substantial shift away from a high percentage of talk time that might be expected was not observed, with an average of 70% of lesson time devoted to talk and only 20% to student activity. Although this is a doubling of activity time, it still means that only 12 minutes of every hour of instruction using the new science curricula would involve student-centered activities. Teachers did lecture less when using the new curricula, but they also tended to engage in more verbal direction giving. The amount of teacher questioning did not change, although more higher level questions were asked. Further there was a slight decrease relative to student-initiated talk. Considering all the above observations it would seem that the intentions of the new science curricula with regard to teaching practice have been less than fully realized.

An additional area of analysis in this study involves the effects of training and supervision on teaching practices. Several issues related to training and supervision merit further discussion. First, what is the nature of the training? As has already been observed, the teachers in activity-oriented classes only devoted an average of 20% total time to activities. Did the training programs themselves provide good activity-oriented models? It is possible that the "training" delivered in summer institutes, for example, was provided under the direction of science content specialists with little or no experience in the new curriculum programs, elementary education, or teacher training. Even if this was not the case and experienced educators were involved, to what extent did the training focus on enabling the teachers to implement desired teaching practices? The present study does not address this question. As a further investigation one could examine the specific nature of the training programs (to the extent this information was reported) and compare the effectiveness of those programs designed to change teaching practice with those of a more general or content oriented nature.

The present study provides a useful model for those involved in synthesizing the findings of many studies on a particular topic. The nature of the data involved in this particular set of studies (percentages of total time) does not seem to lend itself to the usual procedures of meta-analysis employing effect size calculations. The author's methodological approach of stating specific hypotheses, collecting and tabulating appropriate data, and comparing summary data to the hypothesized outcomes appears to be valid for this type of synthesis research.

REFERENCES

Bredderman, T. "Effects of Activity-Based Elementary Science on Student Outcomes: A Quantitative Synthesis." Review of Educational Research 53 (4): 499-518, 1983.

Dunkin, M. and B. Biddle. The Study of Teaching, New York: Holt, Rhinehart and Winston, 1974.

Porterfield, D. R. "Influence of Preparation in Science Curriculum Improvement Study on Questioning Behavior of Selected Second and Fourth Grade Reading Teachers." Doctoral dissertation, The University of Oklahoma, 1969.

Redfield, D. L., and E. W. Rousseau. "A Meta-analysis of Experimental Research on Teacher Questioning Behavior." Review of Educational Research 51: 237-245, 1981.

Shymansky, J. A., W. C. Kyle and J. M. Alport. "The Effects of New Science Curricula on Student Performance." Journal of Research in Science Teaching 20: 387-404, 1983.

Weiss, I. R. Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education. Washington, D. C.; U.S. Government Printing Office, 1978.

MISCONCEPTIONS

Brumby, Margaret N. "Misconceptions about the Concept of Natural Selection by Medical Biology Students." Science Education, 68 (4): 493-503, 1984.

Descriptors--*Biology; *College Science; *Concept Formation; *Evolution; Higher Education; Medical Students; Science Education; Scientific Concepts; Student Characteristics

Expanded abstract and analysis prepared especially for I.S.E. by Richard Tolman, Brigham Young University, Provo.

Purpose

The purpose of the study was to study misconceptions about the concept of natural selection among first year medical students in Australia. The author studied the conceptual frameworks and reasoning patterns used by the students in solving unfamiliar biological problems that are based on real world examples.

Rationale

The conceptual framework dealt with the concept of natural selection as a mechanism of evolution. Natural selection is commonly misunderstood and the investigator was trying to determine the existence of misconceptions in some medical related problems. The research is an extension of studies of basic biological concepts with British tertiary students by Brumby (1981).

Research Design and Procedure

This study was a one-shot case study without a treatment as such specified by the author. One could infer that a year of exposure to an introductory biology course was a treatment for one measure in the study. One could also infer that the treatment was the public school instruction received by the subjects. Although lacking in "rigor," there certainly is a place for this type of research in obtaining baseline data in science education.

The sample consisted of 150 first-year medical students from one Australian university. It should be noted that, in Australia, students enter medical school immediately following the twelfth year of secondary schooling; most of these students were 18 years old. No information was given on how the students were selected, although it appears they might have been members of one specific class in biology.

Three types of instruments were administered to the students. First, in the second week of the first term of the course, two questions were given that required a written, open-ended response. One problem dealt with insecticides and a second dealt with antibiotics. Second, during the next four weeks, structured interviews were conducted with 32 volunteers from the 150 original students. Audio-tapes were made as the students explained the basic concepts or ideas in their written responses to the two questions from the exam. They were then shown a stimulus picture of human skin color variation and asked questions about skin color of adults and their children in Africa and in Scotland. Third, at the end of the school year the students were asked to explain why a member of the medical profession should understand the process of natural selection, and to give two examples of medical importance.

The investigator analyzed the students' written and oral responses in order to identify key concepts and phrases used by the students. There were no a priori categories, rather, the investigator was looking for patterns that emerged from the students' responses. Results were reported for each question that was administered to the students.

Findings

a. Insecticide Problem

Two-thirds of the students recognized that the insecticide problem was based on natural selection of those insects which were already resistant to the insecticide. They also recognized that the period of 20 years over which the insecticide was used represented many insect generations, resulting in an increased frequency of

insecticide resistance in the population. The remaining one-third of the students used phrases such as "the insects adapt," or "gradually become immune" to insecticides. These responses indicate an inference about change within individuals as a mechanism of adapting to the insecticides.

b. Antibiotic Problem

The antibiotic problem was separated from the insecticide problem by another unrelated question. The antibiotic problem proved to be very difficult to be recognized as a problem based on natural selection. Only 21 of the 150 students identified the invading bacterial population as the target of antibiotic treatment and correctly explained this in terms of selection of variation in a bacterial population.

Several different errors in interpretation existed in students' responses. First, half of the students thought that the human body, not the bacteria, was the primary target of the antibiotics. Several conceptual errors in immunology were included in student explanations of their answers. These included the human body becoming immune to antibiotics, the body building up resistance to the healthy properties of penicillin, and a person's metabolism becoming tolerant to the antibiotics. There was also some confusion between antibiotics and antibodies and some students thought that antibiotics were effective against viruses.

c. Interviews

Thirty-two students volunteered to participate in further interviews. They were given back their own answers to the insecticide and antibiotic problems and specifically asked what concepts they were based on. Only one-third mentioned natural selection or evolution. Nearly one-third identified immunity or adaptation as the basal concept, and the remainder focused on the social problems of drugs and drug abuse. To determine the consistency of these responses, the students were asked if the two problems were similar in any way. Several did not see any relationship, and many of those who saw a similarity did not

identify the concept, but focused on content. These responses focused on the commonality being about immunity or changes in the environment. One-third of the students unhesitatingly identified the correct conceptual basis of the two problems as being based on natural selection.

With the skin problem, 9 of the 32 students (28%) explained the answer based on natural selection. The remaining 23 students (72%) explained their answers in terms of adaptation or loss through disuse following migration. When asked to predict the skin color at birth of future children born in different environments, a majority stated that skin color was genetically determined and would be the same as the parents. Nine of the students suggested a change in skin color that would be visible within two generations.

Taking into account the responses of the students across all three problems, only three students (10%) were consistently able to recognize and correctly apply the concept of natural selection. These three students were categorized as having sound understanding. Ten students were able to explain one to two problems and were categorized as having partial understanding. The remaining two-thirds consistently reasoned using concepts of adaptation and immunity and were categorized as having poor understanding. All students categorized as having sound or partial understanding had previously studied biology in the public schools. The majority of those categorized as having poor understanding had not previously studied biology.

d. End-Of-Year Question

One-third of the 150 students correctly explained the effect of natural selection on the frequency of genetic disorders. One-third focused on the environment in their explanations of the applications of the problems to the medical profession. Although one-fourth of all examples of medical importance included sickle-cell, only a minority of those answers adequately explained balanced

polymorphism and included correct genetic terms such as alleles or heterozygotes.

Interpretations

The author concluded that the majority of the students in the study left school believing that evolutionary change occurs as a result of need, which is a Lamarckian view. Students believe that organisms become more immune rather than more organisms become immune. Even though some lectures on evolution occurred while the oral interviews were taking place, there did not seem to be any impact of the lectures on the student explanations. The errors made by the students were cited as being far more than simple errors of knowledge, but rather coming from a faulty reasoning pattern. Students have the incorrect observation that individuals can change their characteristics during their lifetime and that these characteristics can be passed on to their offspring. Adaptation was confused with immunity, and immunological concepts such as resistance, tolerance, and antibodies were introduced incorrectly.

ABSTRACTOR'S ANALYSIS

a. The Relationship of the Study to the Matrix of Other Studies in the Area of Research

There are really only two other studies that are directly applicable to this research and those are the papers published by the author herself of studies done in England. The author has reviewed the pertinent related literature in the introduction of this paper. The related papers include work done on students' perceptions of concepts associated with the physical world by Nussbaum & Novak (1976); Driver & Easley (1978); Erickson (1979); Osborne & Gilbert (1980); Gunstone & White (1981); Champagne, Klopfer, & Gunstone (1982); Posner, Strike, Hewson, & Gertzog (1982). Students' perceptions of concepts associated with the living world have not been

studied as extensively as those for the physical world, but the author cited some relevant research on misunderstandings and intuitive, nonscientific explanations dealing with biological concepts. These works are those by Deadman & Kelly (1978); Stead (1980); Goldman & Goldman (1982).

b. New Conceptual Contributions of the Study

There are no new conceptual contributions of this study, but rather a confirmation of the intuitive feelings of experienced biology teachers that students do not understand the concept of natural selection. University level biology instructors also report a lack of understanding of natural selection by students in introductory biology courses. If the author's study were carried out in U. S. universities, I would predict that a similar outcome would occur after exposure to general biology at the institutions of higher education.

c. New Methodological Contributions of the Study

No new methodologies were used. These same techniques have been used in the studies cited above and by persons involved in research in information processing by students at high school and university levels.

d. Validity of the Study

The study is valid, but due to some inherent problems in the design, the results cannot be extrapolated to the population in general. There is a place in science education research for the gathering of baseline data, which was done in this study.

e. Comments on Research Design

The design was adequate, but some improvements could be suggested for other researchers. Instead of asking for volunteers for the oral interviews, a random selection of students would have resulted in data that could be generalizable to the population of the study. Because all of the interviews were conducted with volunteers, no randomness can be assumed and the students cannot be viewed as representing all students who participated in the study.

f. Comments on the Adequacy of the Written Report and Suggestions for Improvement

The report is generally well written, but some improvements could be made. A reference to the specific design would have been helpful, as well as more elaboration on the constitution of the population. After reading the entire paper, it becomes clearer that the population consists of all of the students in a general biology class. This should have been stated in the description of the population.

The data are presented in a clear and precise manner in the tables. In the narrative, however, the author uses the terms, "many," "a majority," "the last few," "only a minority," etc. This forces the reader to continually turn back and forth between tables and text pages, which could be overcome by being more precise with these statements in the text of the paper.

g. Assessment of the Current State of Research in the Particular Area of Study

This particular area of research is really in its infancy. There is a lack of data on student misconceptions where test data are followed up by student interviews to get at what the students are actually thinking as they respond to questions. Information processing research into genetics problem solving is proceeding, but few other areas of the life sciences are being investigated with interview techniques.

h. Suggestions for Future Research Direction and Effort

With the creation/evolution arguments occurring all over the U. S. and in some other countries, it would be important to obtain baseline data on student perceptions in this area. There is simply too much misinformation around that fuels fires for pseudoscience and pseudoscientific arguments. A possible outcome from this type of research may be some new teaching suggestions that could help students overcome these misunderstandings. This research could also be broadened to include information processing research techniques where students could talk out loud while they are solving the actual problems instead of just giving ex post facto responses about why they answered as they did.

REFERENCES

Brumby, M. "The Use of Problem-Solving in Meaningful Learning in Biology." Research in Science Education, 11: 103-110, 1981.

Brumby, M. "Students' Perceptions of the Concept of Life." Science Education, 66 (4): 613-622, 1982.

Champagne, A. B., L. E. Klopfer and R. F. Gunstone. "Cognitive Research and the Design of Science Instruction." Educational Psychology, 17 (1): 31-53, 1982.

Deadman, J. A. and P. J. Kelly. "What do Secondary Schoolboys Understand About Evolution and Heredity Before They are Taught the Topics?" Journal of Biological Education, 12: 7-15, 1978.

Driver, R. and J. Easley. "Pupils and Paradigms: A Review of Literature Related to Concept Development in Adolescent Science Students." Studies in Science Education, 5: 61-84, 1978.

Erickson, G. L. "Children's Conceptions of Heat and Temperature. Science Education, 63: 221-230, 1979.

Goldman, R. and J. Goldman. Children's Sexual Thinking. London: Routledge & Kegan Paul Ltd., 1982.

Guilbert, J. J. "Basic Issues In Curriculum Design and Implementation." Symposium paper presented at the ASME/SRHE conference: "Approaches to Curriculum Design and Evaluation: The Medical Experience." London, England, November 1977.

Gunstone, R. F. and R. T. White. "Understanding of Gravity." Science Education, 65 (3): 291-299, 1981.

Nussbaum, J. and J. K. Novak. "An Assessment of Children's Concepts of the Earth Utilizing Structured Interviews." Science Education, 60 (4): 535-550, 1976.

Osborne, R. J. and J. K. Gilbert. "A Method for Investigating Concept Understanding in Science." European Journal of Science Education, 2 (3): 311-321, 1980.

Posner, G. J., K. A. Strike, P. W. Hewson and W. A. Gertzog. "Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change." Science Education, 66 (2): 211-227, 1982.

Stead, B. Living (Working Paper 15). Waikato, N.Z.: Learning in Science Project, University of Waikato, 1980.

Andersson, B. "Pupils' Explanations of Some Aspects of Chemical Reactions." Science Education, 70 (5): 549-563, 1986.
Descriptors--Chemical Reactions; *Chemistry; Cognitive Development; Cognitive Structures; *Concept Formation; Concept Teaching; Inquiry; Science Education; *Science Instruction; Science Teachers; *Scientific Concepts; Secondary Education; *Secondary School Science

Expanded abstract and analysis prepared especially for I.S.E. by Glen Aikenhead, University of Saskatchewan, Saskatoon.

Purpose

The article synthesizes and reviews six studies related to grade 7 - 9 students' common sense explanations of chemical reactions ("children's science" or "alternative frameworks"). Two general purposes are (1) to stimulate further investigation in the area, and (2) to improve chemistry teaching and textbooks. In its function as a synthesis, the article introduces a tentative categorization scheme that allows researchers or teachers to make sense out of what students say about chemical changes -- "how students explain the appearance and disappearance of substances."

Rationale

The article is logically embedded in the constructivist view of learning, in the conceptual change perspective on teaching, and in the alternative framework research program. The reasons for writing a review article, rather than reporting new research, were stated by the author: (1) discussants at recent international symposia on alternative frameworks were not acquainted with the studies in chemical change, and (2) the studies themselves had made no reference to each other. It was assumed that future work in this area ought to be informed by the findings of the six pertinent studies, and that future research and chemistry teaching would be enhanced by an improved categorization scheme with which to interpret student statements.

Research Design and Procedure

The article introduces a new research tool and demonstrates its use. More specifically, the author posits a five-category scheme for interpreting student statements about chemical change, and then demonstrates its effectiveness by re-analyzing results reported in six studies on students' common sense explanations of chemical change. The design and procedure of these six studies conformed to the normal pattern of alternative framework research, although they varied in (1) the puzzles that students addressed (e.g., copper pipes oxidizing, alcohol combusting, copper sulfate dehydrating, and cars burning fuel), (2) sample size, and (3) the data gathering techniques employed (e.g., written responses and personal interviews).

The author contrasts his new categorization scheme with the schemes used in the original studies.

The discussion section shifts the focus of the article from explicating the new research tool to reflecting upon the pedagogical significance of the research findings.

Findings

The reader is left to decide which is the most effective categorization scheme, one of the old ones or the new one. The new scheme uses the following categories of student explanations for the appearance and disappearance of substances:

A. It is just like that (A nonexplanation)
B. Displacement (Change of location; a physical change)
C. Modification (Change of form; a physical change)
D. Transmutation (Alchemy)
E. Chemical interaction (The conventional scientific conception)

Categories B to E are each composed of two perspectives: (1) reasoning about the macroscopic world, and (2) reasoning about the atomic world. Thus, the new scheme is summarized in the article by a two-dimensional table.

Interpretations

The article reflects upon the pedagogical significance of the findings on conceptual change found in the six studies reviewed. The following points are made by the author:

a. Students try "to understand something new by assimilating it to existing cognitive structures."

b. Students' common sense conceptions "of chemical reaction can interact with school teaching so that misunderstanding arises." That is, instruction which naively ignores students' preconceptions (their common sense conceptions) can reinforce these "misconceptions." "Conceptions that the teacher introduces as an alternative must also be experienced as comprehensible and better." Misunderstanding the nature of scientific models can interfere with desired conceptual change. Thus, textbooks often create misunderstandings by not dealing adequately with the nature of scientific models.

c. Appropriate instruction leads a student (1) to become aware of his or her own common sense conception of chemical change, (2) to treat this as a hypothesis, (3) to use it in an inquiry process in order to determine its usefulness, and (4) to examine the teacher's (or textbook's) conception as an alternative hypothesis to his or her own. A concomitant condition for appropriate instruction is the psychologically safe and supportive classroom atmosphere. Careful attention must be paid by the teacher to the use of language.

d. Chemistry instruction in grade 8 seems to cause little conceptual change in students. This may be due to the difficulty of the concept or to inadequate instruction. "Many improvements to textbooks and teaching are desirable."

The author's valid claim that student conceptions of chemical change needed to be reviewed is supported not only by the author's evidence, but also by the topic's absence in the West and Pines (1985) volume Cognitive Structure and Conceptual Change. The legitimacy of a review article is clearly illustrated in this case.

There is a strong correspondence between the substantive results of the six studies reviewed by the author, and the general findings of the common sense or alternative conceptions research program. This strong relationship reinforces the findings concerned with conceptual change. The present article is a forum for revisiting those findings.

In addition to commenting on the difficulties encountered by teachers or researchers trying to change students' conceptions, the author offers a tentative categorization scheme which seems to be a useful tool for inferring what students believe. Thus, the article makes two substantial contributions to the science education literature. In the eyes of this reviewer, these contributions are just as worthwhile to the chemistry teacher down the hall as they are to the research program on alternative frameworks.

Having pointed out the utility of this review article, I should like to suggest that a greater utility would accrue from a broader review, one which would encompass other research programs such as the Piagetian studies completed by such researchers as Dudley Herron. We know that teachers eclectically and idiosyncratically apply psychological theories when they plan instruction (Roberts, 1980). Thus, a review that caters to the teacher's eclectic use of knowledge may be more effective in improving classroom instruction. Such a review constitutes a realistic and worthwhile direction for future articles concerning students' explanations of chemical change.

The author's discussion of conceptual change was clearly informed by the six studies reviewed and was enriched by the results of the common sense conception research program. One critical point seems to be missing in this explicit discussion, however: the role of student evaluation. (This issue is implicit in the author's discussion of the classroom psychological atmosphere and in his call for "new teaching methods.") From a student's perspective, the curriculum is defined, by and large, by what is evaluated. Thus, the most ingenious teaching

strategies for promoting conceptual change will be wasted unless a corresponding evaluation strategy is developed. (Students will likely memorize the teacher's conception). The author's excellent suggestion that students treat their own conceptions as hypotheses requires a concomitant evaluation strategy such as a check list (Lansdown et al., 1971, ch. 8) that will help teachers monitor the desired behavior in students. (Tests cannot assess how well students learn from their mistakes, for instance.) Given that one of the stated purposes of the review article was to improve chemistry teaching, the pivotal importance of student evaluation techniques should not be ignored. Helping teachers evaluate student conceptual change should be part of any practical review. The categorization scheme devised by the author is an excellent step in that direction.

Further research in the classroom setting could focus on the strategies naturally designed by practitioners when they utilize the author's new categorization scheme; that is, how does the scheme fit into the functional paradigms of teachers (Lantz & Kass, 1986)? The goals of conceptual change must be operationalized for students in terms of how students are evaluated. Research and development in this direction is needed just as much as new instructional material and strategies are.

REFERENCES

Lansdown, B. et al. Teaching Elementary Science Through Investigation and Colloquium. New York: Harcourt Brace Javonovich, 1971.

Lantz, O. and H. Kass. "Chemistry Teachers' Functional Paradigms." Science Education, 71 (1), 117-134, 1986.

Roberts, D. "Theory, Curriculum Development, and the Unique Events of Practice." In H. Munby et al. (eds.) Seeing Curriculum in a New Light: Essays from Science Education. Toronto: OISE Press, 1980.

West, L. and L. Pines. Cognitive Structure and Conceptual Change. New York: Academic Press, 1985.

INSTRUCTION

Allison, A. Wayne and Robert L. Shrigley. "Teaching Children to ask Operational Questions in Science." Science Education, 70 (1): 73-80, 1986.

Descriptors--*Elementary School Science; Intermediate Grades; *Questioning Techniques; Science Education; *Science Instruction; *Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by Donald E. Riechard, Emory University.

Purpose

The purpose of the study was to determine the effects of teacher modeling and student practice on the number of operational questions written by students. More specifically, the investigators wanted to know which of the following groups would write the greater number of operational questions:

1. Students whose teacher modeled operational questions (T_1), or students not involved in the treatment (T_c)?
2. Students whose teacher not only modeled operational questions, but also involved students in practice at writing operational questions (T_2), or students not involved in the treatment (T_c)?
3. Students whose teacher modeled operational questions (T_1), or students whose teacher not only modeled operational questioning, but also invovled students in practice at writing operational questions (T_2)?

Rationale

The primary assumption undergirding this study was that asking operational questions could help young students learn inquiry science. The assumption was derived from a belief that variable manipulation through asking operational questions might lead to a clearer understanding of cause and effect relationships.

Alfke's (1974) work served as the basic model for teacher-student use of operational questions in investigating common science phenomena. Literature on the role of teacher modeling in developing student questioning skills and research on cognitive dissonance support the study's design.

Research Design and Procedure

Seventy-two fifth and sixth grade students from a rural school district in central Pennsylvania were randomly assigned to the three treatment groups. Three female teachers with similar teaching credentials, and whose teaching expertise had been observed and appraised by one of the investigators, served as teachers in the study. In four one-hour training sessions, teachers were prepared to conduct all three treatments. Teachers were then assigned randomly to T_1, T_2, T_c for the first week of the study. In an attempt to control teacher effect, each teacher was rotated to another group each week so by the end of the three-week study each teacher had taught each group for five days.

The T_1 group received the following treatment:

1. Introduction to science concept.
2. Science demonstration by teacher.
3. Three or four teacher-made questions drawn from the science demonstration were modeled on an overhead transparency. The teacher reviewed with the students the criteria for formulating operational questions and the teacher's questions were studied. Students in T_1 wrote no questions.

The T_2 group had an added component. Following the science demonstration and a review of the characteristics of operational questions, subjects were directed to write operational questions related to the science demonstration viewed moments earlier. Finally, students were asked to compare their questions to the teacher's model questions written to represent that particular demonstration.

The T_c group was the control group. Subjects in this group merely viewed a filmstrip dealing with the same science content covered in the T_1 and T_2 groups. Teachers' comments were limited to the script accompanying each frame. Subjects reviewed the filmstrip orally but there was no mention of operational questions.

The pretests and posttests involved a science demonstration and discussion followed by asking the subjects to write questions which would help them understand the demonstration. Using Alfke's (1974) definition of operational questions, responses were classified as operational, nonoperational, or nonclassifiable.

Findings

Scores used in data analyses were the mean number of operational questions written by the subjects in each of the three groups (T_1, T_2, T_c). Analysis of variance (ANOVA) on pretest scores yielded a nonsignificant F-ratio (preset alpha level for the study was .05).

When posttest scores were subjected to analysis of variance, the F-ratio was significant at $p < .05$. The Tukey honestly significant difference test (HST) was used to test the difference between mean scores. The mean posttest scores of the groups were $T_1 = 2.12$ (error, see abstractor's notes); $T_2 = 3.04$; $T_c = 0.17$. The HST produced the following results:

1) $T_1 \times T_c$ ($p < .05$)
2) $T_2 \times T_c$ ($p < .05$)
3) $T_1 \times T_2$ ($p = .05$)

Interpretations

It was concluded that subjects experiencing teacher modeling and subjects experiencing both teacher modeling and written practice wrote significantly more operational questions than subjects having neither treatment. Further, subjects experiencing both teacher modeling and written practice wrote significantly more questions than subjects experiencing only teacher modeling.

The investigators identified several interesting relationships including the weekly variations in performance of the three groups. The authors were cautious in interpreting and generalizing their results and concluded by saying that operational questioning may be a window through which teachers and students might examine the innards of inquiry teaching.

ABSTRACTOR'S ANALYSIS

Related Literature

As stated previously, this investigation is grounded in Alfke's (1974) model for operational questioning. While a good bit of other

research exists on such things as levels of questions (recall, application, synthesis, etc.) and wait-time, there is little on operational questioning. I am reminded of two of the Sputnik-era (1960's) curriculum projects and the relationships they have to this study. One is Science-A Process Approach (S-APA) in which one of the higher level science processes was defining operationally. What is the relationship between the skills of stating an operational definition and of being able to ask an operational question? Is there possibly a hierarchy where one skill (along with its subcomponents) would logically come before the other?

Another curriculum project of the 1960's, the Inquiry Development Program (IDP), used discrepant science events to encourage children to ask questions. How successful was IDP in promoting an appreciation and understanding of scientific inquiry? How widely was IDP used? IDP was only physical science. Is it as easy to demonstrate discrepant events in life science and earth-space science as it is in physical science?

The use of discrepant events to promote learning is related to Festinger's (1957) theory of cognitive dissonance and Palmer's (1965) research on the growth of knowledge through cognitive conflict.

Piaget's work in genetic epistemology, however, is often considered basic to understanding the role of cognitive dissonance in learning. According to Piaget, when new information is assimilated from the environment, that new information upsets existing mental equilibrium. An increase in knowledge occurs when the new information is accommodated to what was already in the mind and a new equilibrium is restored (Stendler, 1971).

Related research on teacher modeling and questioning includes the work of Zimmerman and Pike (1972), Henderson and Garcia (1973), and Manzo and Legenza (1975). These studies combined teacher modeling with some other strategy.

Contributions

The present investigation deals with cognitive dissonance, opertional questions, teacher modeling, and student practice. In the past, those areas have represented important topics of research.

Review of current literature, however, suggests that none of the areas is presently receiving much attention. Perhaps the major contribution of this study is that it might revive interest in some very promising lines of research related to student learning in science. Emphasis over the past 10 to 15 years on back-to-basics, teacher accountability, and student performance on standardized tests seems to have diverted attention away from teaching inquiry and problem solving skills.

Research Design

The research design is a pretest-posttest control-group design with two experimental treatments. Using the Campbell and Stanley (1963) format, it can be diagramed as follows:

R O X_1 O
R O X_2 O
R O O

The design leaves several external sources of invalidity uncontrolled. However, it does control for a number of internal sources and is quite appropriate to accomplish the purpose of this study. The design gives a good comparison between the two experimental groups (X_1 and X_2). It is the case, however, that the design diagramed above is oversimplified in that the control group did receive some treatment (filmstrip and discussion). The investigators pointed out the possible difference in effect of viewing a demonstration of a discrepant science event and watching a content filmstrip. They urged caution in interpreting results and recommended that other studies be designed to determine the effect of different levels of cognitive dissonance. I agree.

The good use of randomization strengthens this design. As shown in the diagram, subjects were randomly assigned to groups. In addition, teachers were randomly assigned and rotated among the groups in an effort to control teacher effects. Despite the possibility (as suggested by the authors) that the effort might not have been a total success, it was, nevertheless, a legitimate attempt at increasing the validity of the investigation and a good plan to copy.

Written Report

The written report is conservative in its use of tables. It did not include, for example, tables on the ANOVA and HST analyses. Publication manuals generally suggest that all primary data analyses be summarized in table form. Results in this study, however, were clearly presented in the text and the omission of tables did not greatly detract from its overall merits.

Table 1 shows a T_1 mean posttest score on operational questions to be 2.12. My calculation indicates that it should be 2.29 (55/24). Also, the text shows a difference between T_1 and T_c mean posttest scores of 2.00. The difference is 2.12 (2.29 - .17). I have not rerun the ANOVA and HST analyses but I doubt that these small differences would affect the results.

In discussing results, the investigators identified several hypotheses supported by their findings. The statements of the problem and procedure, however, make no mention of hypotheses. The problem was outlined in the form of three questions. Thus, it seems inappropriate to identify hypotheses in the discussion of results. I'm not convinced that hypotheses are even necessary in a study such as this but if they are to be used they should be stated at the outset of the study.

While I have made some minor suggestions above, the investigation and written report seem well done. The report is clear, concise, and easy to read. Rationale is strong and convincing. The authors' interpretations and conclusions were appropriate to the design of the study and the results obtained. Alternative interpretations were provided for some results and the investigators were cautious not to overgeneralize.

Future Research

As implied above, I think there is need for renewed interest in research on teaching and learning of scientific inquiry. Studies such as the one reviewed here can make an important contribution. Additional questions that might be examined include:

1. At what age can children be taught to formulate operational questions? For example, is the skill teachable to Piaget's preoperational level?

2. What are the effects of different levels of cognitive dissonance on the writing of operational questions?
3. Is there a hierarchy of skills involved in the formulation of operational questions?
4. Does the ability to write operational questions lead to better understanding of science? Better control of variables in science experiments? Better use of scientific methods? Creative problem solving?

REFERENCES

Alfke, D. "Asking Operational Questions." Science and Children, 11: 18-19, 1974.

Campbell, D. and J. Stanley. "Experimental and Quasi-Experimental Designs for Research on Teaching," in N. L. Gage (ed.), Handbook of Research on Teaching, pp. 171-246, Chicago: Rand McNally, 1963.

Festinger, L. A Theory of Cognitive Dissonance. Stanford: Stanford University Press, 1957.

Henderson, R. G. and A. B. Garcia. "Effects of Parent Training Program on the Question-Asking Behavior of Mexican-American Children." American Educational Research Journal, 10: 193-201, 1973.

Manzo, A. V. and A. Legenza. "Inquiry Training for Kindergarten Children." Educational Leadership, 32: 479-483, 1975.

Palmer, E. L. "Accelerating the Child's Cognitive Attainments through the Inducement of Cognitive Conflict: An Interpretation of the Piagetian Portion." Journal of Research in Science Teaching, 3: 318-325, 1965.

Stendler, C. B. "Piaget's Developmental Theory of Learning and its Implications for Instruction in Science," in E. Victor and M. Lerner (eds.), Readings in Science Education for the Elementary School, 2nd. Edition, pp. 379-391, New York: Macmillan, 1971.

Zimmerman, B. J. and E. O. Pike. "Effects of Modeling and Reinforcement on the Acquisition and Generalization of Question-Asking Behavior." Child Development, 43: 892-907, 1972.

James, R. K. and S. Smith. "Alienation of Students from Science in Grades 4-12". Science Education, 69 (1): 39-45, 1985.
Descriptors: *Attitude Change; *Blacks; *Elementary School Science; Females; *Instructional Program Divisions; Intermediate Grades; Science Education; Secondary Education; *Secondary School Science; Student Alienation; *Student Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Edmund A. Marek, University of Oklahoma, Norman.

Purpose

The purpose of the study reported in this article was to gather and examine data regarding the grade level(s) in school at which alienation from science occurs. Alienation, as used in this report, was defined in terms of declining science subject preference and attitude scores of students in cross-sectional samples of adjacent grade levels. The specific research questions were:

(1) Between which grade levels do subject preference and attitude toward science scores have their largest decline for all students?

(2) Between which grade levels do subject preference and attitude toward science scores have their largest decline for black students?

(3) Between which grade levels do subject preference and attitude toward science scores have their largest decline for female students?

Rationale

The researchers cited several studies which served as a useful foundation for examining the alienation of students from science. Bloom (1976) related interest in science to achievement and reported moderate positive correlations between these two factors at the eighth and twelfth grades. Furthermore, the correlation was higher for science than with other subjects and the correlation coefficients

increased with grade level. The National Assessment of Educational Progress (NAEP) (1977) reported that science was named after math, language, social studies, and "other" by nine, thirteen, and seventeen year old students who were asked about their favorite subjects. Welch (1983), working with thirteen and seventeen year olds, reported declines in interest and achievement in science. Additional evidence of the alienation of students from science was provided in the research of Miller and Remick (1978) and Bayer (1973). They reported lower enrollments in high school chemistry and physics especially among female and black students.

Research Design and Procedure

The Sample. Over 6,000 students were used in this study and these students were drawn from three districts in Kansas with populations greater than 40,000. This sample had an adequate racial and gender mix, was suburban, and was located near the researchers. All three districts had adopted science programs which, although not identical, were developed during the late 60s and early 70s under the sponsorship of the National Science Foundation.

The Instrument. There were three parts to the data gathering instrument. Section I assessed the student's subject-preference by listing pairings of each subject with all subjects. Science occurred five times, therefore scores ranged from zero to five on Section I. Section II assessed students' attitudes with thirteen items using a Likert-type scale. Nine items involved attitudes toward science as a school subject and four items involved attitudes toward science related employment. Scores ranged from 1 (most negative) to 5 (most positive). Responses in Section III provided the following demographic data: ethnicity, gender, grade, and current enrollment in science.

Reliability was assessed and a Pearson correlation coefficient of 0.77 was reported. Readability of early fourth grade was assessed with the Fry procedure. Analysis of variance for statistical significance of the differences between means for grade levels of the cross-sectional groups was employed using the Scheffe' Test.

A two-way ANOVA (alpha = 0.05) was used to examine the alienation towards science between females and males and between blacks and the general population.

Findings

The researchers of this study discovered clear patterns in the data. For the total student population, the largest decreases in positive attitudes occurred between the 6th and 7th grade levels as demonstrated with significant (0.05) F values for 13 of 14 items. (Similar results occurred on some items for grades 4-5.) This trend was repeated for blacks--11 of 14 survey items showed the greatest decrease in means at the 6th or 7th grades. And again, when examining the attitudinal data of the females in the study, the largest decrease in positive attitudes occurred between the 6th and 7th grades (decreased means on eleven of the fifteen survey items).

Science Subject Preference means for item number one were presented graphically for the total student population of the study, the blacks and the females. Blacks of this study had a greater science subject preference in the lower grades but were at or below the population for the higher grades. Female students in the study were at or below the total population group and the black student group across all grade levels.

Interpretations

The researchers of this study were careful not to generalize their results regarding alienation of students from science but they recommended that concerned school districts could conveniently conduct such a study and analyze their students' science-attitudinal trends.

Several "...disturbing explanations..." were offered for the dramatic decline in positive attitudes toward science at the seventh grade:

(1) 7th grade is often the first time science is a separate subject taught in a separate classroom and a required subject,

(2) 7th grade may be one of the earliest attempts where students are required to use self-directed problem solving techniques to a greater degree than in earlier grades which the researchers identify as added rigor, and

(3) grades K-6 science is usually not graded, therefore 7th grade may be the first time a student's science work is evaluated.

The researchers pointed out that their data caused them to question the tendency to blame negative attitudes toward science on poor science teaching in elementary school. They concluded "...Cleverly conceived, well prepared, adequately equipped, and properly supervised science experiences probably can improve students' attitudes toward science. One of the implications of this study is the challenge remaining in early junior high science...".

ABSTRACTOR'S ANALYSIS

Perhaps the most important finding in this genre' of research is the grade level at which the greatest amount of alienation toward science occurs -- between the sixth and seventh grades. Several research questions could be posed: What does middle/junior high school science do to students? How does secondary school science differ from elementary school science? What is the nature of science programs in middle/junior high school? What is the emphasis of elementary school science: the science program or the science content? What is the focus of secondary school science: the student or the science content or both?

The early years of this decade saw many reports of crises in science education which described declining enrollments and declining test scores in science (Marek, 1985). Also repeatedly reported were the negative attitudes toward science, especially in middle/junior high school. The National Science Board Commission on Precollege Education in Mathematics, Science, and Technology (1983) reported that approximately 50% of the students entering junior high school held positive attitudes toward science while only 21% of the students leaving junior high school had positive attitudes toward science. In other words, these first three years of secondary school science were successful in developing negative attitudes toward science! With

these data in mind, the reader is invited to again consider the question posed in the last paragraph.

Shymansky, Kyle and Alport (1982) analyzed numerous studies which compared the performance of students in traditional textbook-centered science classrooms with students of process-approach science programs. The students in the process-approach science classrooms performed better than 62% of the students in the traditional classrooms on attitudes, achievement, process skills, creativity and cognitive development. The implications for science teaching are clear, but the report also states that few elementary school teachers are using such programs. In fact, very little (one in 25 hours) or no time is devoted to science in elementary schools which causes this researcher to pose a hypothesis: If very little or no elementary school science teaching exists and attitudes toward science are more positive with elementary school students than with entering high school students who have had three years of traditional textbook-centered science programs in junior high school then fewer negative attitudes toward science will be developed if students have no traditional textbook-centered science.

The purpose of the research abstracted here was to collect and analyze data regarding the grade level(s) at which alienation from science occurs in school. That purpose was fulfilled with the instrumentation and research design of this project. A suggestion, which could serve to improve the written report, would be to include, in the results section, more examples and explanations of specific interpretations of the data (e.g., the particular attitudes at each grade level) and more discussion of each item on the research instrument. The authors offer several interpretations and conclusions in the Discussion section which were valid but to have expanded upon these explanations would have been useful. For example this expanded explanation could have included related research. Finally, this abstractor would echo a recommendation listed in the article: "...school districts that are concerned about alienation of their students from science need not rely on the external validity of this study. The survey could conveniently be conducted and analyzed for their specific district...".

REFERENCES

Bayer, A. E. "The New Student in Black Colleges." School Review, May, 1973.

Bloom, B. S. Human Characteristics and School Learning. New York: McGraw-Hill, 1976.

Marek, E. A. "Science Education: Its Problems and Crises." The Journal of Professional Studies, 11 (1), 12-14, 1985.

Miller, K., and H. Remick. "Participation Rates in High School Mathematics and Science Courses." The Physics Teacher, 280-282, May, 1978.

National Assessment of Educational Progress. "The Third Assessment of Science." 1976-1977. Released Exercise Set. Contract #OEC-0-74-0506, 1977.

National Science Board Commission on Precollege Education Mathematics, Science and Technology. "Today's Problems, Tomorrow's Crises." The Journal of College Science Teaching, 12: 346-349, March/April, 1983.

Shymansky, J. A., W. C. Kyle, Jr., and J. M. Alport. "How Effective were the Hands-On Science Programs of Yesterday?" Science and Children, 20, 14-15, Nov/Dec, 1982.

Welch, W. W. National Assessment of Education Progress News. 16 (2), 1983.

Yore, Larry. "The Effect of Lesson Structure and Cognitive Style on the Science Achievement of Elementary School Children." Science Education, 70 (4): 461-471, 1986.

Descriptors--*Academic Achievement; Classroom Techniques; *Cognitive Style; Elementary Education; *Elementary School Science; Grade 4; Grade 5; *Learning Strategies; Science Education; *Science Instruction; Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by John W. Renner, University of Oklahoma, Norman.

Purpose

This research was designed to find whether or not the achievement of elementary school students who have a low perceptual structure can be assisted by increasing the inquiry lesson structure in science. The perceptual structure factor was measured by cognitive style and the research accepted the Witkin description of cognitive style as being a combination of personality and cognition traits. Three null hypotheses relating to cognitive style, lesson structure and their interaction were stated.

Rationale

The rationale for this research has its roots in those teaching and learning procedures that can be called inquiry oriented. The position that such teaching and learning procedures are based upon the structure of science is assumed. Two treatments were used which were based upon the inquiry principle--those treatments were called the semi-deductive approach and the teacher-structured method.

Specific problems were introduced to the group in the semi-deductive approach and the students were encouraged to fully investigate those problems by developing their own experimental procedures using the available materials. After the student investigations were completed, a class discussion was held to enable the students to synthesize ideas and generalizations. Study guides,

overt teacher direction, and experimental procedures were given to the students during the teacher-structured method. After the structured investigation, a class discussion was held during which data were analyzed, results were summarized, conclusions developed and practical applications were discussed. The rationale for this research was that the foregoing lesson structures would have a positive influence on students with a low perceptual structure.

Research Design and Procedure

Cognitive style and lesson structure were the independent variables in the research and student achievement in science was considered to be the dependent variable. The research used a two-part, two-group, post-test-only design. The first part (treatment) the students experienced was on the subject of magnets. This treatment consisted of seven 40-minute lessons presented over a four-week period. One group experienced the semi-deductive treatment and the other group was taught with teacher-structured procedure. Content-specific, teacher-made achievement tests were administered at the end of the four-weeks of instruction. The second treatment the two student groups experienced was structured around the unit entitled Mystery Powders. That treatment consisted of six 40-minute lessons conducted over a four week period. Again student achievement was measured with a content-specific teacher-made test at the end of the four week period. An applications test was administered after the completion of the second treatment. During the second treatment the groups were instructed with the teaching procedure they had not experienced in the first treatment.

The two groups consisted of a total of 40 students drawn from a middle-class, racially-mixed, English-speaking population located near Victoria, B.C., Canada. The sample's age range was nine years, two months to twelve years. Group One was made up of 6 grade four and 14 grade five students; Group Two consisted of 7 grade four and 13 grade five students. One entire 40-student, open-area class was used.

The student's cognitive styles was measured with the Group Embedded Figures Test (GEFT). The test manual reports reasonable

validity for the GEFT because it correlates well with other measures of cognitive style. The GEFT's reliability is reported as 0.82. In other words, the lesson structure independent variable was purposefully designed into the research and the cognitive style independent variable was measured.

The dependent variable, student achievement in science, was measured with teacher-made achievement tests and one laboratory test. The achievement test on Treatment One (magnets) consisted of 38 written items of the matching, true-false, or fill-in-the-blank types; the test's reliability is reported as 0.91. The written examination on Mystery Powders contained 20 fill-in-the-blanks and completion items; a reliability coefficient of 0.82 is reported. In addition to the written tests, student achievement was measured with a 24-item unstructured analysis of unknown mixtures test (the laboratory test). Individual students analyzed two different unknown mixtures of the six substances used; 35 different combinations of two or three substances were randomly assigned as unknowns and students did not receive the same unknown for the two analyses. A reliability coefficient of 0.66 is reported.

The data resulting for the measurement of the dependent variable--student achievement--were analyzed using a two-way analysis of variance. The data which resulted from the measurement of one of the independent variables with the GEFT, --cognitive style--were clustered into two intervals: low cognitive style (GEFT 0-6) and high cognitive style (GEFT 7-18). A treatment-by-cognitive style matrix was prepared for each of the three measures of student achievement, i.e., the 38 item test on magnets, the 20 item test and the laboratory test on Mystery Powders. That matrix contained the means, standard deviations, and sample sizes for each treatment and cognitive style.

Findings

After treatment, the low cognitive style group--which was composed of field dependent students--had a mean GEFT score of 3.96 across the entire range of 0-6. The high cognitive style group was composed of field independent persons and had a mean GEFT score of 11.12; those scores ranged in value from 7-17.

The descriptive data indicate that generally the field independent learners had slightly higher science achievement regardless of the topic--magnets or Mystery Powders, or teaching procedure--semi-deductive mode or teacher-structured mode-used. High structure produced higher achievement in the magnets unit and lower achievement in the Mystery Powders unit. The student achievement data for the magnets topic demonstrated that a significant contribution had been made to the variance for the cognitive style dimension ($F=8.34$, $p=0.01$). No significant contributions were found for the lesson structure dimension ($F=0.23$, $p=0.63$) or the interaction of cognitive style and lesson structure ($F=0.14$, $p=0.71$). The data analysis of the Mystery Powders test showed a significant contribution to the variance of the cognitive style dimension ($F=5.60$, $p=0.02$) but none for the lesson structured dimension ($F=1.81$, $p=0.19$) or for the interaction of the cognitive style and lesson structure ($F=0.29$, $p=0.59$). The data analysis of the laboratory test indicated a significant contribution to the variance for the cognitive style dimension ($F=11.17$, $p=0.00$) but none for lesson structure ($F=0.62$, $p=0.44$) or the interaction of cognitive style and lesson structure ($F=0.10$, $p=0.76$).

Interpretations

In the study of magnets, increasing the lesson structure did increase student achievement very slightly but not significantly so. That finding was not made for student achievement on the Mystery Powders unit. Increased lesson structure cannot be said, therefore, to have significantly improved science achievement in this research. The researcher speculates that the instance of slightly higher achievement could be due to an artifact of sampling, the match between instruction and achievement measure, or the difference between the two treatments is trivial. The teacher-structured instructional procedures employed with the study of magnets suggests a similarity of structure between the teacher-structured mode and the testing procedure. That similarity is suggested because the magnets test required students to respond to structured questions and did not require the use of any innovative thinking or problem solving. The teacher-structured approach was described earlier as being quite directive.

Only slight student achievement differences were found on both evaluations done on the Mystery Powders unit. The low lesson-structure group performed slightly better on both evaluations; that is the same group of students that scored slightly higher with the high-structured treatment in their study of magnets. The researcher attributes the slight differences found to sample differences.

The use of the GEFT in this research to measure cognitive style produced definitive results. Field-independent students achieved significantly higher science scores than did the field-dependent students. The research reports that analyses of the treatments and tests indicate a direct association between the abilities the GEFT measures and those required for science instruction and testing. Those abilities relate to intellectual activities which require extraction, restructuring and application in a different context. The lack of interaction found between cognitive style and lesson structure supports the belief that external structure of lessons cannot compensate for the lack of internal structure of field-dependent learners. The report concludes by stating that perhaps the two treatments used--semi-deductive and teacher structured inquiry--were not significantly different in their perceptual-intellectual demands since "the source of structure was confounded and the content determined the lower limit of the lesson structure."

ABSTRACTOR'S ANALYSIS

This research provided a model which can be replicated because it described the teaching procedures (treatments) which the students experienced. The semi-deductive approach and the teacher structured method are described in enough detail to enable research to be done with them in the future with materials different from those used in the present research. A future effort will enable the results found here to be compared with results from using different materials which are employed by different researchers.

The experience the 40 participating fourth and fifth grade students had with the two teaching procedures was seven 40-minute lessons on magnets and six on Mystery Powders. Furthermore, those

lessons on each topic were experienced over a four-week period. In other words, the students experienced 13 inquiry lessons in a period of eight weeks. The report does not state whether or not the two four-week periods were contiguous.

Thirteen inquiry lessons in 40 school days (eight weeks) may not have provided sufficient experience to test the three null hypotheses stated in the report. Additional information regarding the nature of the structure of the remainder of the students' days is not given. If, for example, the students experienced inquiry-centered teaching during the remainder of the day, perhaps the 13 inquiry lessons would be sufficient to test the stated hypotheses. Suppose, however, the students experienced the remainder of the day being subjected to exposition. In that case 13 lessons would not seem enough to permit the students to learn what they are expected to do in an inquiry-centered classroom. In other words, there are student responsibilities in the two teaching procedures used that are different from the responsibilities a student has in an exposition-centered classroom and students must have time to learn what those differences are and how to respond to them. To expect differences beyond those shown in the report seems optimistic, with such a brief treatment over a rather extended period of time. The differences shown in the report could lead to the inference that, had the period of the treatment been longer, perhaps some of the non-significant differences included earlier would have been significant. To completely test the hypotheses stated in the research report, it is felt that the treatment period needs to be increased. In other words, perhaps the researcher is expecting too much achievement from two treatments which are too short.

Tests for the importance of the cognitive style dimension of the research were significant. That significance shows the importance of field independence to inquiry-centered teaching and learning in science. A lengthening of the treatment beyond the 13 lessons would allow that importance to be further evaluated.

Leonard, William H. and Lawrence F. Lowery. "The Effects of Question Types in Textual Reading Upon Retention of Biology Concepts." Journal of Research in Science Teaching, 21 (4): 377-384, 1984.

Descriptors--*Biology; *College Science; Higher Education; *Questioning Techniques; *Reading Comprehension; *Retention Psychology; Science Education

Expanded abstract and analysis prepared especially for I.S.E. by Joel J. Mintzes, The University of North Carolina at Wilmington.

Purpose

This study examined the relative effects of several types of interspersed questions in textual readings on acquisition and retention of biological concepts in an introductory-level university course. Specifically, the investigators studied the extent to which "rhetorical," "factual," "valuing," and "hypothesizing" questions affected the learning of concepts concerning multicellularity.

Rationale

The effects of questions placed within textual materials have been studied extensively, especially in the social sciences and languages (Rothkopf and Bisbicos, 1970; Reynolds et al., 1974; Watts and Anderson, 1971). Questions placed after readings have been found to be significantly more productive than prequestions. However, the effect of placing questions directly within the textual narrative has been much less researched, and "the effect of this interspersed questioning strategy as part of science textbooks is apparently unresearched to date." Although the authors hypothesize "for experimental purposes" that interspersed questions would not significantly boost learning, the research they cite suggests that this "null hypothesis" is certainly contrary to their working assumption.

Research Design and Procedures

Three hundred eighty-three (383) students who enrolled in a one-semester general biology course at the University of Nebraska were randomly sorted into six treatment groups of approximately equal size. Students in each of the groups, except the last, read a 2769-word passage on the concept of multicellularity taken from a popular university general biology textbook (Kirk et al., 1978). The following is a summary of the treatments:

Group	Treatment
One	Reading without interspersed questions
Two	Reading with (24) rhetorical questions interspersed at the beginning of selected paragraphs
Three	Reading with (24) factual questions
Four	Reading with (24) valuing questions
Five	Reading with (24) hypothesizing questions
Six	No reading

Operationally, "rhetorical" questions were defined as those that do not require participation by the reader, while "factual" questions require recall or recognition of specific information. "Valuing" questions ask the reader to make a judgment or explain an evaluation, and "hypothesizing" questions require a prediction or explanation for a question, problem, or situation.

Following the treatments, a 20-item multiple-choice test (KR_{20}=0.67) composed of recall and application questions was administered to all students at three intervals: immediately after the reading (time 0); two weeks after the reading, and nine weeks after the reading.

To examine the effects of the treatments, two types of data analyses were performed:

1. Dunn's "Multiple Comparison" (t) procedure was used to test differences in achievement among groups at each of the three time intervals, and
2. A multivariate trend analysis and post hoc pairwise contrasts were employed to document overall differences in achievement across the three time intervals.

Findings

The findings of the study can be summarized as follows:

1. At time 0, no differences were found between students receiving interspersed questions (of any type) and those receiving no questions; furthermore, students who read the passage (regardless of treatment group) outscored students who did not read the passage.
2. At two weeks, students who received no questions surpassed all other groups; furthermore, the "no reading" group was outscored only by those receiving no questions and "hypothesizing" questions.
3. At nine weeks, students who received no questions surpassed only the "no reading" group and those receiving "rhetorical" questions; furthermore, no differences were found between those receiving the "rhetorical" questions and students who had not read the passage.
4. The trend analysis indicated significant differences (and a significant interaction effect) between treatment groups when the data were considered across the three time intervals. However, pairwise contrasts between students who received no questions and each of the other groups indicated that the former differed only from those students who did not read the passage and those receiving "rhetorical" questions. "...only the reading with rhetorical questions and no reading groups had trends significantly lower than the no-questions group."

Interpretations

The authors drew several conclusions from the study:

1. "...students do appear to show significant gains in test scores from reading biology text..."
2. "...understanding and retention of biology concepts... was (sic) not enhanced by frequent questions of any type... In many cases, inserted questions appeared to result in less learning."

3. "The results of this study differed considerably from those of most reported studies..."
4. "...we have no explanation at this time for the results of this experiment." "Perhaps such interspersed questions did distract the students' concentration...perhaps biology text had unique characteristics...perhaps the position or method of presentation were critical variables."

ABSTRACTOR'S ANALYSIS

Relationship to Other Studies

In the abstract of the paper, the authors provide a helpful review of previous research on the effects of questioning strategies in oral instruction and textual materials. The studies they cite are especially pertinent in light of the findings the present authors report, which appear to be quite inconsistent with those of previous workers. How can we account for the apparent discrepancies between the present findings and those reported earlier? Have the authors stumbled on a significant, but previously unrecognized, phenomenon? Or, may we conclude that this study contains some serious methodological and/or conceptual flaws? Only by carefully comparing the present study with previous studies can we hope to answer these questions.

One weakness in the present study is the absence of a strong, coherent, theoretical framework. Such a framework can improve the written report in several ways. It can make the problem itself more meaningful by enabling the researchers to speculate on the underlying cognitive processes that might account for the efficacy of a given instructional strategy. (Why, for example, should interspersed questions enhance learning, anyhow? What cognitive functions are stimulated or triggered by these questions? Can these functions be triggered in other ways?)

Furthermore, whenever the findings of a study are inconsistent with previous findings (as these are), a theoretical model can serve a strong explanatory or heuristic function. In its absence, the researchers (and the readers) are left groping for potential explanations ("perhaps...perhaps...perhaps").

Contributions of the Study

The issues addressed by this study are indeed significant ones. College science students rely heavily on textbooks as a primary source of information, and any strategy that might enhance learning from textual materials would certainly be welcomed by students themselves and by instructors, textbook authors and publishers.

Unfortunately, the present study seems to "muddy the water" on the issue of questioning strategies. What are we to conclude from this study?; that interspersed questions are of little value in teaching biology concepts?; that such questions may even inhibit or depress learning? How can these conclusions be reconciled with those of other studies?

Of all the findings, the one that appears most convincing is that "...students show significant gains in test scores from reading biology text." Is this surprising? Does it warrant eight pages in a scientific journal?

Research Design

Several methodological and design problems seem evident in this paper, and each may have contributed to the discrepant findings of the study. The principal issues of concern are: the treatment itself, the subjects, and the methods of data analysis.

Treatment: The authors indicate that "shortly after the second test...all students...received approximately 20 minutes of lecture instruction on multicellularity." While admitting that this instruction may have introduced "a new variable," the authors seem at great pains to suggest that "lectures on multicellularity were the same for all students," that "...a natural learning environment was preserved in this experiment," and that "...confounding variables have been controlled for."

Unfortunately, it is virtually impossible for the reader to assess these claims as pertinent information has been omitted. One might ask, for example: Were all students enrolled in the same lecture section? Did the same instructor teach all students? (Can lectures ever be the same unless students are actually enrolled in the

same class, at the same time, with the same instructor?) Did all students read the same sections of the assigned textbook? Which textbook was actually assigned in the course, and how similar were the pertinent passages to those read in the study? Did students have differential access to any additional, outside sources of information that might bear on the results of the study?

Subjects: The authors tell us that the students were "randomly sorted" into treatment groups, but fail to indicate how this was accomplished. Were the students pretested? Did they differ in their prior knowledge of biology concepts? Did they differ in reading ability or comprehension? These issues are of considerable importance in a study of reading and learning in biology. Although a "quasi-experimental" design based on random assignment may be acceptable as a minimal standard, the findings of this particular study might have been more persuasive if the researchers had established no differences among treatment groups at the outset of the experiment.

Data Analysis: This study purports to examine the effects of questions in textual readings on learning in biology. The appropriate "control group" in such a study is a "reading without questions" group (which the researchers provide). However, they also included a "no reading" group in the design. While this group provides an interesting contrast to the others in the univariate analyses, it does introduce still another variable in the study.

The authors are unclear on this point, but it appears that data from the "no reading" group were included in the multivariate trend analysis. If so, how does one unambiguously interpret the findings of significant differences? Were they caused by the "reading effect" or the "question effect"? The pairwise contrasts suggest that the "no reading" group probably accounts for the greatest variance among the groups. If the "no reading" group had been omitted from the trend analysis, would significant differences still be found?

Written Report

The written report is comprehensive in its treatment of experimental procedures and results and, given the limitations of the study, the discussion is forthright and the conclusions appear to be

consistent with the findings. Two questions of minor concern: Why was the literature review embodied in the abstract?; Why does the abstract not summarize the methods and results of the study?

Further Research

The authors suggest that, "...the same experiment needs to be replicated and also conducted for other biology concepts..." Their suggestion is a good one. However, in replicating this study, care should be taken to avoid similar methodological pitfalls encountered in this effort.

Specifically, a more controlled experimental environment must be established. The study should be conducted outside of the context of an established course in biology; the experimental design should include pre- and post-testing of students, and potentially confounding variables must be eliminated in the analysis of the data.

REFERENCES

Kirk, D., R. Taggart and C. Starr. Biology: The Unity and Diversity of Life. Belmont, CA: Wadsworth, Inc., 1978.

Reynolds, R. E., S. N. Standiford and R. C. Anderson. "Distribution of Reading Time When Questions are Asked About Restricted Category of Text Information." Journal of Educational Psychology, 66: 354-362, 1974.

Rothkopf, E. Z. and E. R. Bisbicos. "Selective Facilitative Effects of Interspersed Questions on Learning From Written Materials." Journal of Educational Psychology, 61: 417-42, 1970.

Watts, G. H. and R. C. Anderson. "Effects of Three Types of Inserted Questions on Learning From Prose." Journal of Educational Psychology, 62: 387, 1971.